CERES Energy Balanced and Filled (EBAF) Edition4 Plans

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EBAF Ed2.8 (Current Version)

- Essentially a hybrid of:
  - Clouds & ADMs used in CERES SSF Ed2 (same as Ed3)
    - => GEOS 4 (03/2000-12/2007), GEOS 5.2.1 (01/2008-)
    - => MODIS Collection 4 (03/2000-04/2006) & 5 (05/2006-)
  - TOA fluxes determined using Ed3 calibration coefficients
- While input changes have minimal impact on all-sky TOA fluxes, they cause discontinuities in clear-sky TOA fluxes (through scene identification) and all-sky and clear-sky surface radiative fluxes.
- Consequently, there's a spurious trend in TOA Cloud Radiative Effect.
- EBAF-SFC makes adjustments to minimize impact of input changes.

EBAF Ed 4.0 (Future Version)

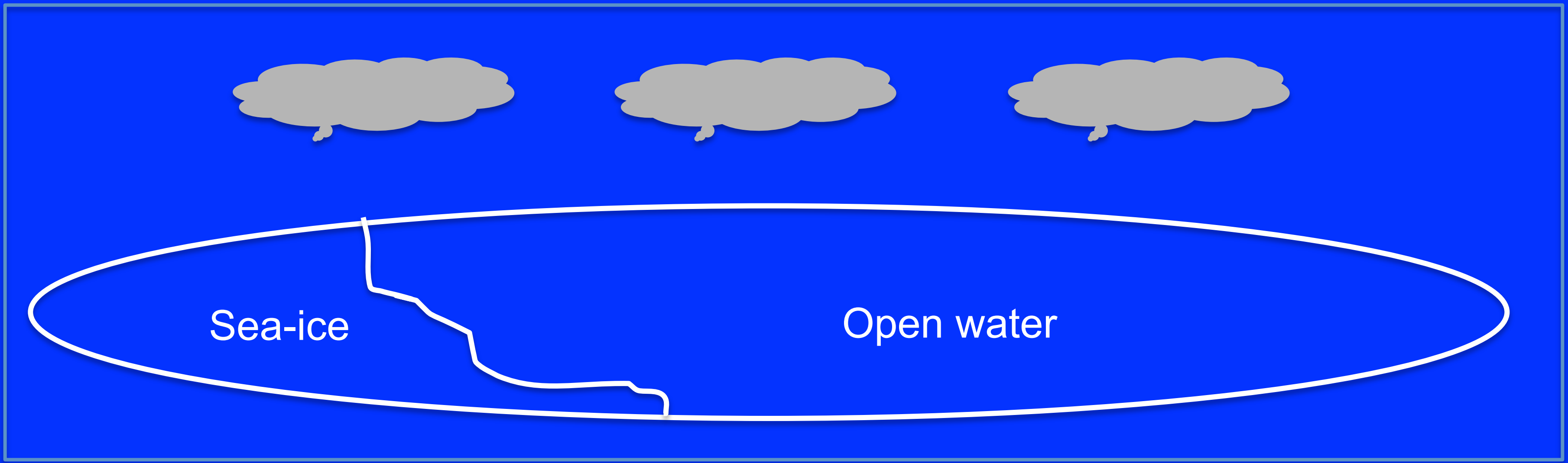
- Will incorporate all of the Ed4 algorithm improvements:
  - Improved instrument calibration
  - Cloud properties
  - ADMs
  - Surface flux calculations
  - Time Interpolation and Space Averaging (with hourly GEOs)
  - Will be based upon consistent met assimilation (GEOS 5.4.1), MODIS radiances and aerosols (Collection5, until that gets superseded by C6)
- Will incorporate refinements to the EBAF high-resolution clear-sky TOA fluxes, particularly for footprints with snow & sea-ice.
  - New narrow-to-broadband regressions (use more MODIS bands & Ed4.0 CERES radiances)
  - Estimate clear-sky fluxes for footprints with partial snow and sea-ice coverage.
- TOA fluxes will be constrained using same approach as EBAF Ed2.8 (Argo constraint).

- Plan is to initially release 5 years (2005-2010) by early 2016.
- EBAF Ed2.8 will continue to be produced until EBAF Ed4.0 catches up.

EBAF Clear-Sky TOA Radiative Flux: (Very) Preliminary Results

- EBAF includes clear-sky fluxes from cloud-free CERES footprints & estimates from clear portions of partly cloudy CERES footprints.
- Here we show expected differences between clear-sky TOA fluxes in EBAF Ed4.0 and EBAF Ed2.8
- Estimated using data in Ed3 SSF and new Ed4 SSF for Terra
  - Differences due to:
    - Different MODIS cloud mask, ADMs
    - Use of additional MODIS channels in narrow-to-broadband regression
    - Inclusion of footprints partly covered by snow or sea-ice.
- Convert gridded instantaneous differences to 24-h averages using TISA code employed in EBAF Ed2.8.
- Caution: These are only estimates—not all steps in EBAF process are included here.

Clear-sky Flux for Partly Cloudy Footprints with Partial Snow/Sea-ice Cover



EBAF Ed2.8 (Method 1)

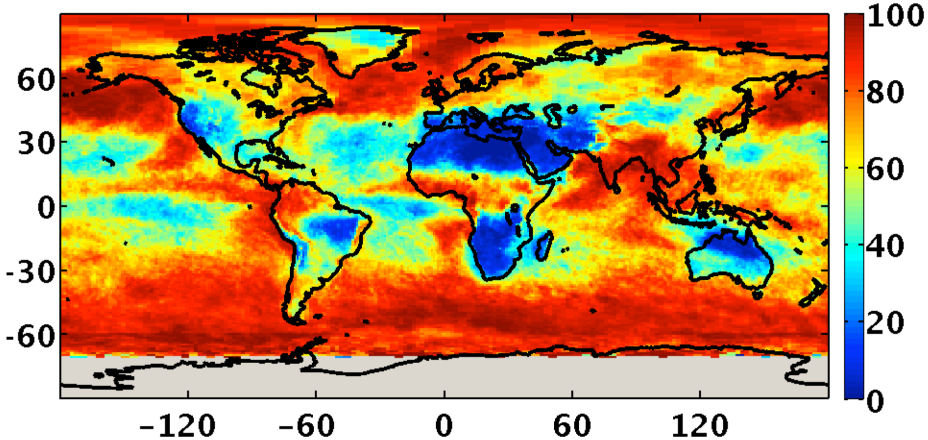
- MODIS/CERES regressions uses only 5 MODIS channels available in Ed3 SSF.
- Only estimate high-resolution clear-sky flux if FOV is partly cloudy and has 100% sea-ice, 100% open water or 100% land coverage.

EBAF Ed4.0 (Method 2)

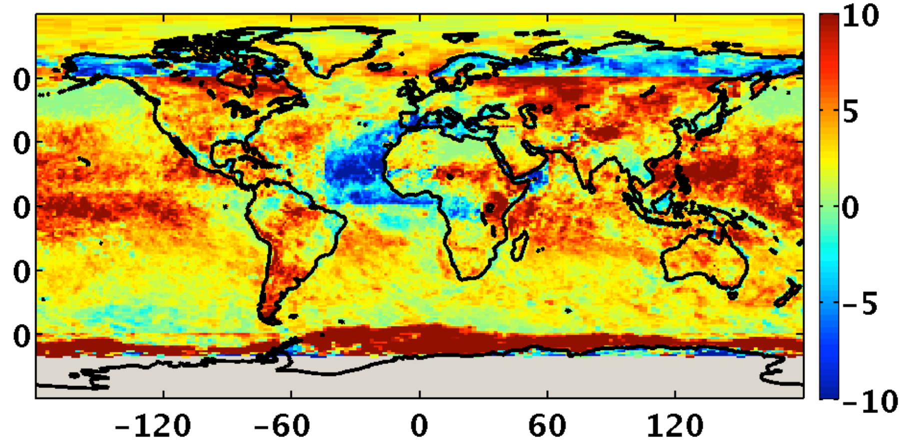
- MODIS/CERES regression uses many more MODIS channels available in Ed4 SSF.
- Estimate high-resolution clear-sky flux if FOV is partly cloudy and partly sea-ice/ water or partly snow/land. Apply both sets of regressions to clear-sky radiances and weight by surface type coverage.

Daytime Cloud Fraction: Ed4 vs Ed3 (200407)

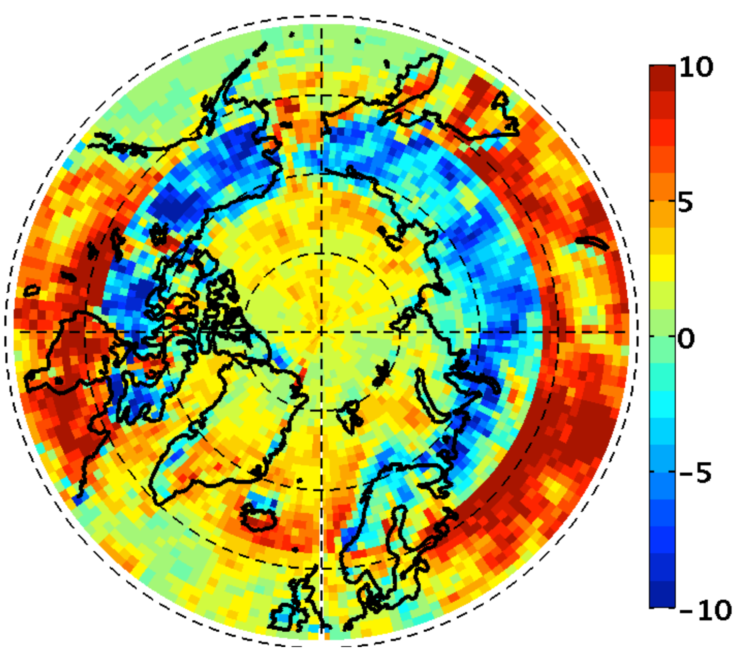
Mean Ed4 Cloud Fraction (Glob Mn = 66%)



Ed4 minus Ed3 (Glob Mn = 3.1%)



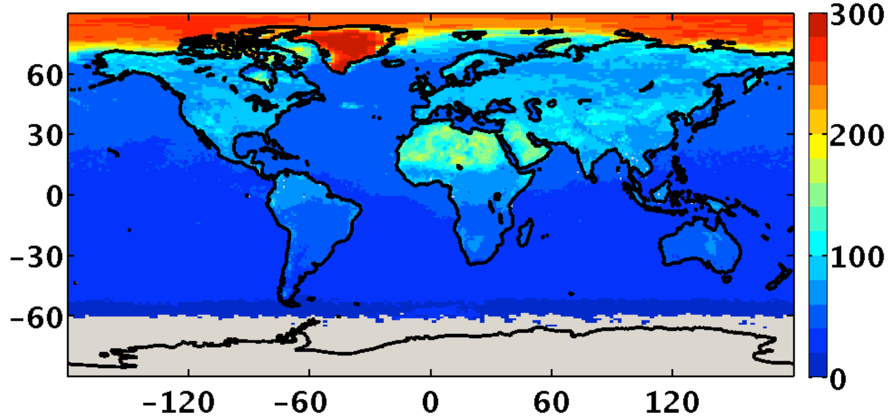
Ed4 minus Ed3 (Glob Mn = 3.1%)



- Increase in cloud fraction in Ed4 everywhere except west of Saharan Desert & over land north of 60°N.
  - -> Ed4 corrects misclassification of dust as cloud in Ed3.
  - -> Known discontinuity at 60°N in Ed3 from switch between daytime & nighttime cloud mask.

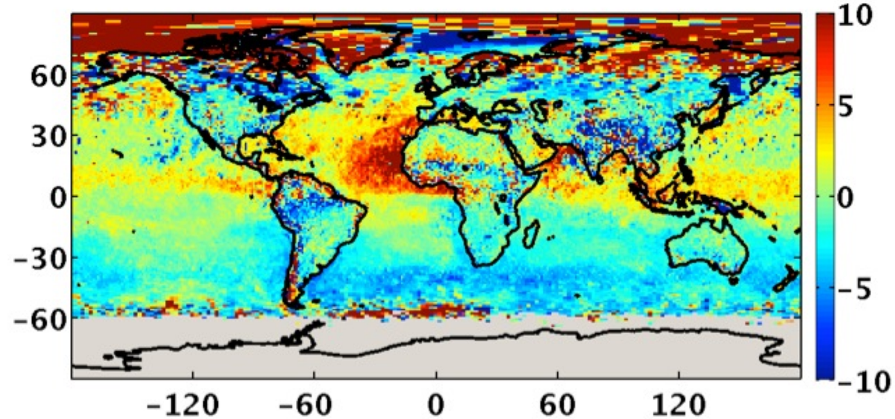
Estimated EBAF High-Resolution Clear-Sky SW TOA Flux Diff (200407)

Mean Ed4.0 (Method 2)



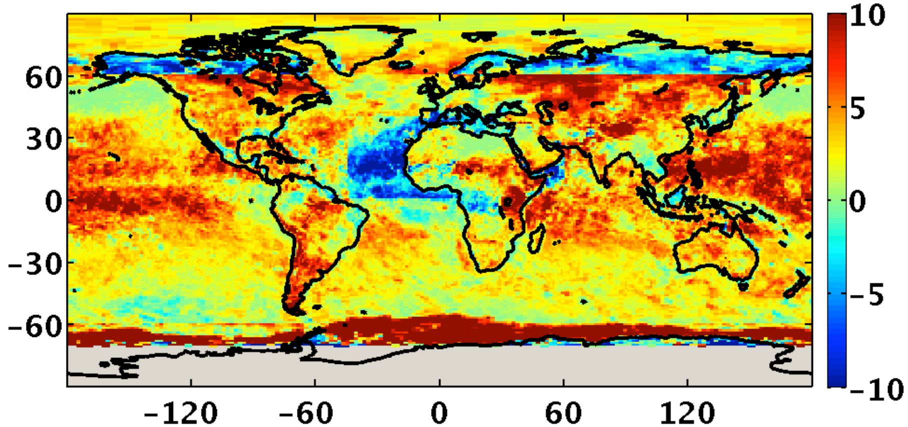
Global mean = 52.5 Wm^{-2}

Ed4.0 (Method 2) minus Ed2.8



Global mean = 0.97 Wm^{-2}

Ed4 minus Ed3 Cloud Fraction

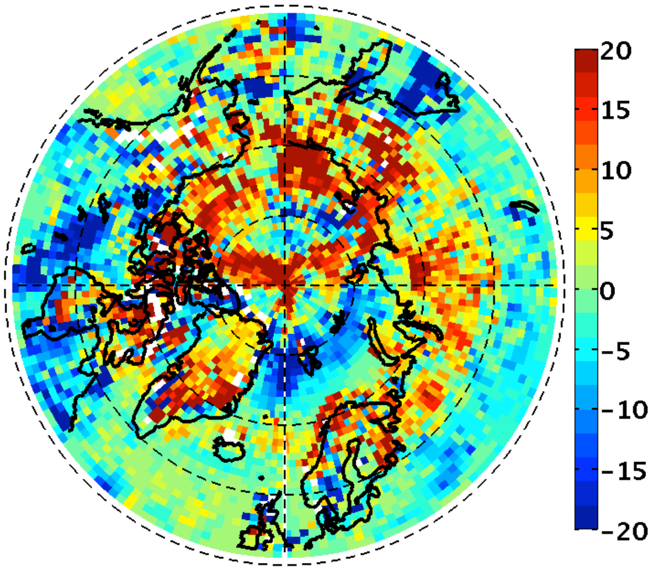


Global mean Diff = 3.1%

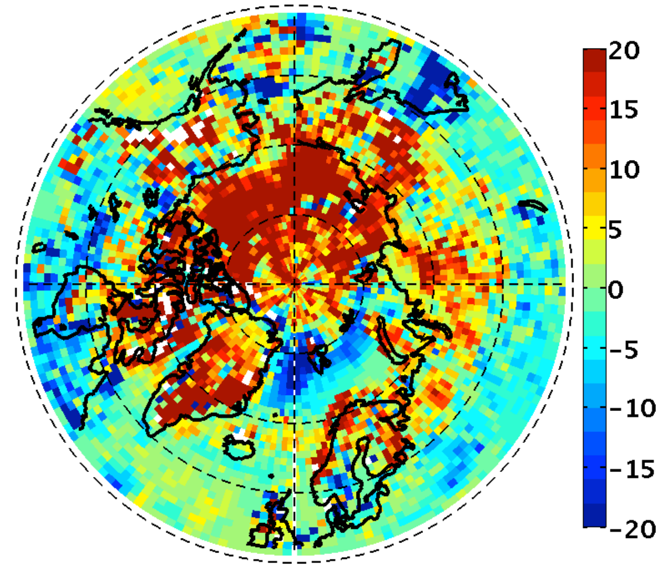
- Increases of 10 Wm^{-2} or more for Saharan dust over ocean.
- Decreases of up to 5 Wm^{-2} over Southern Oceans

Estimated EBAF High-Resolution Clear-Sky SW TOA Flux Diff (200407)

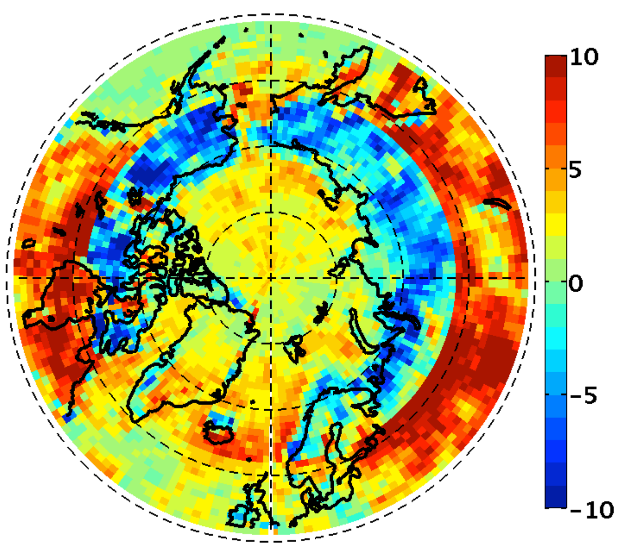
Ed4.0 (Method 1) minus Ed2.8



Ed4.0 (Method 2) minus Ed2.8



Ed4 minus Ed3 Cloud Fraction

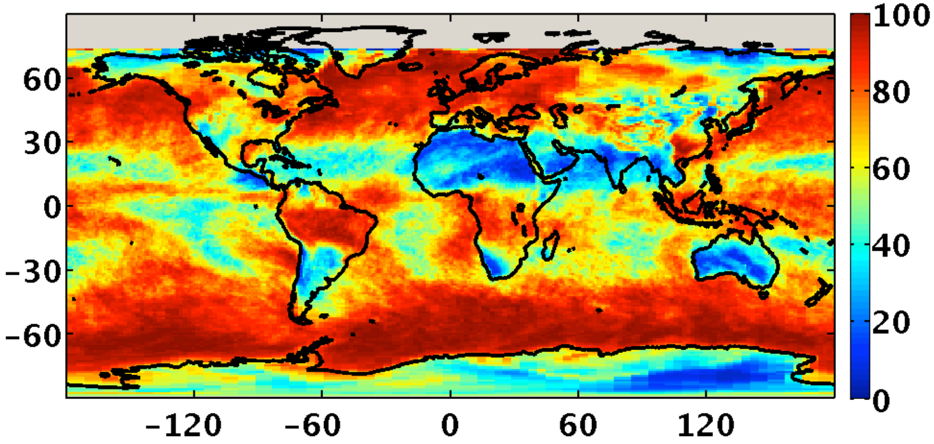


- Inclusion of partly cloudy FOVs with partial sea-ice coverage increases clear-sky SW TOA flux over Arctic Ocean.

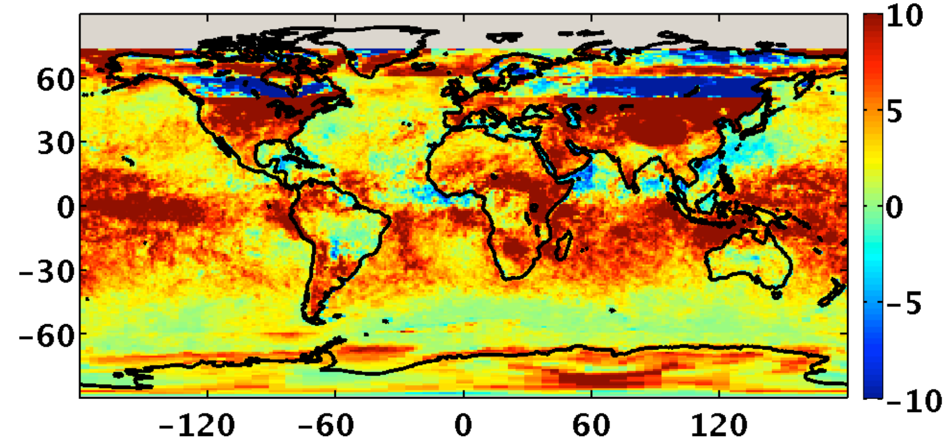
  -> Ed2.8 excluded many FOVs with high partial sea-ice coverage.

Daytime Cloud Fraction: Ed4 vs Ed3 (200401)

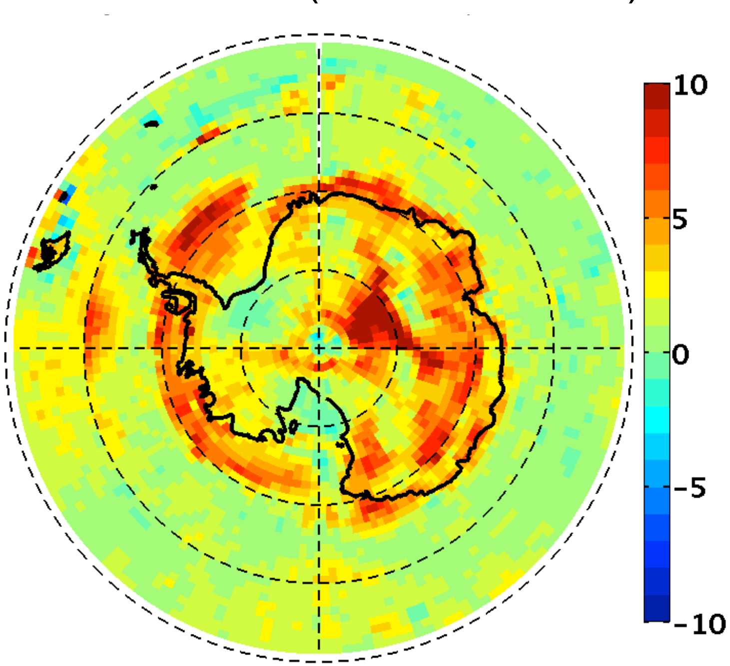
Mean Ed4 Cloud Fraction (Glob Mn = 67%)



Ed4 minus Ed3 (Glob Mn = 4.4%)



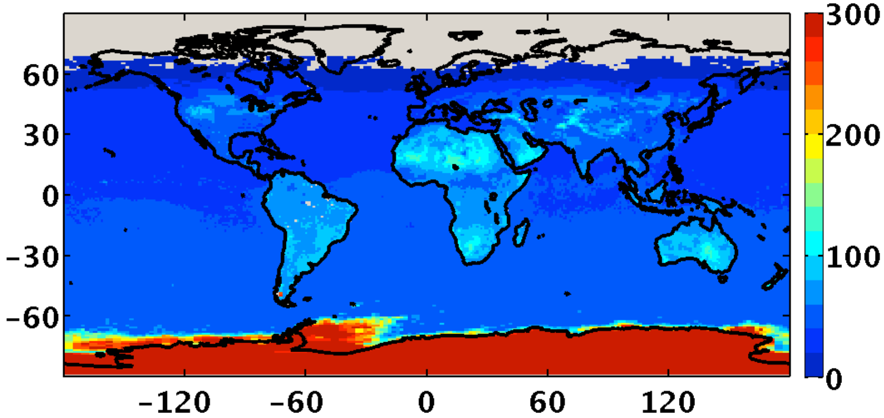
Ed4 minus Ed3 (Glob Mn = 3.1%)



- Increase in cloud fraction in Ed4 greatest for ocean 0°-30°S and NH midlatitude land sourth of 60°N.

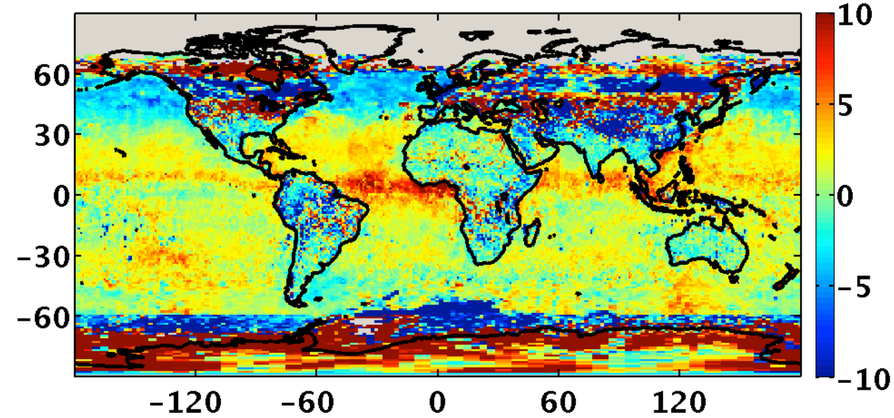
Estimated EBAF High-Resolution Clear-Sky SW TOA Flux Diff (200401)

Mean Ed4.0 (Method 2)



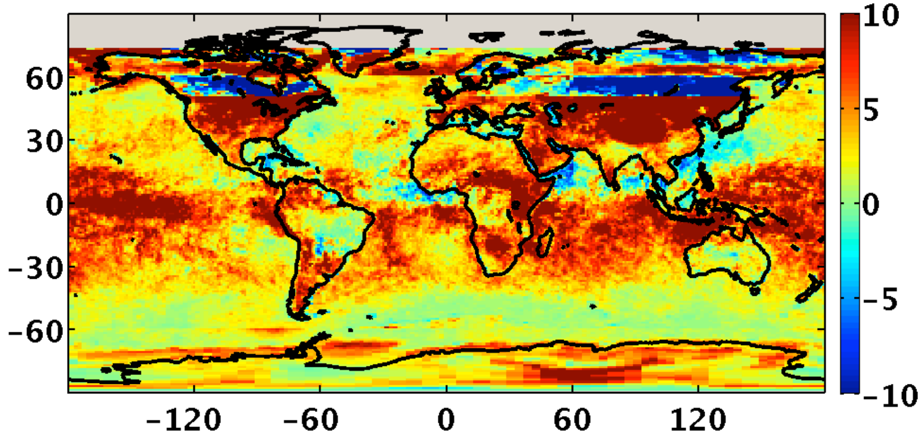
Global mean = 55.9 Wm^{-2}

Ed4.0 (Method 2) minus Ed2.8



Global mean = 1.6 Wm^{-2}

Ed4 minus Ed3 Cloud Fraction

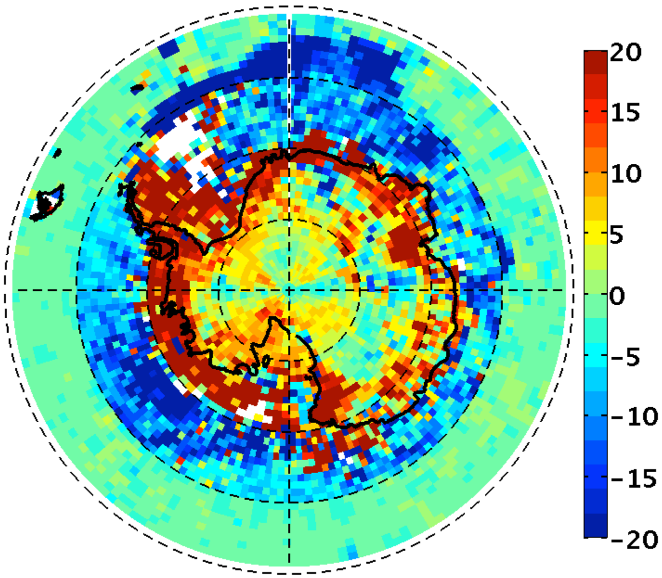


Global mean Diff = 3.1%

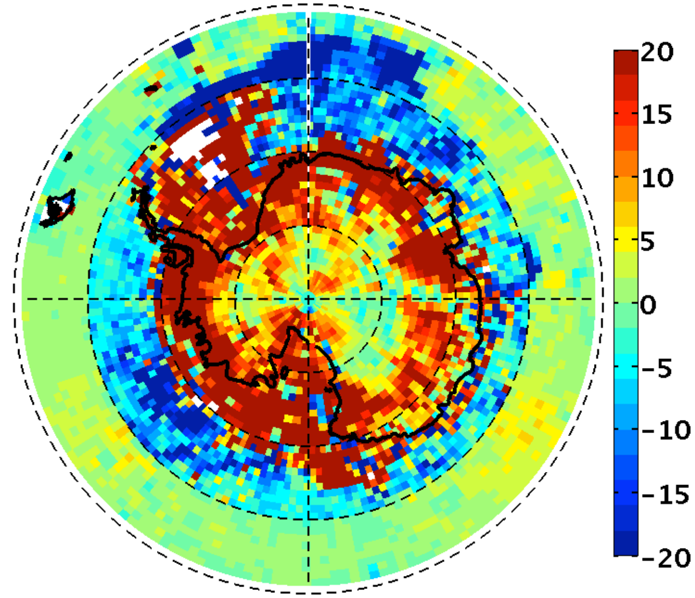
- Clear-sky SW TOA flux differences generally positive over ocean and negative over land.

Estimated EBAF High-Resolution Clear-Sky SW TOA Flux Diff (200401)

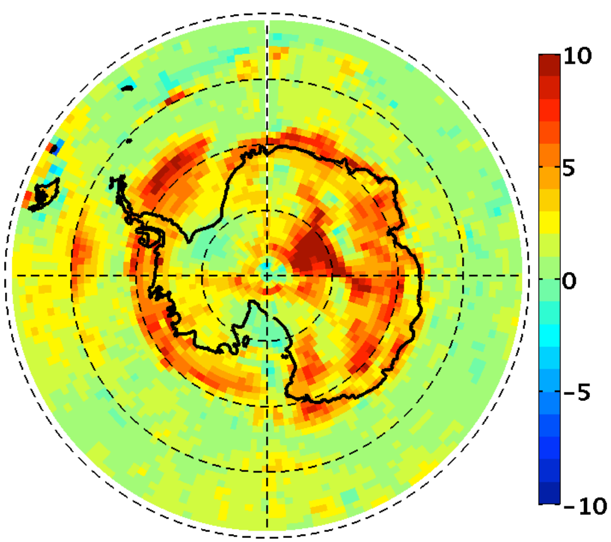
Ed4.0 (Method 1) minus Ed2.8



Ed4.0 (Method 2) minus Ed2.8



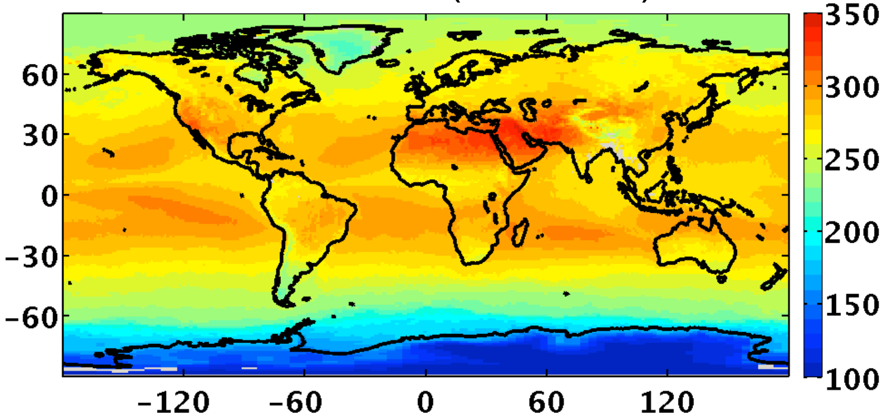
Ed4 minus Ed3 Cloud Fraction



- Larger difference in Ed4.0 (Method 2) compared to Ed4.0 (Method 1) over permanent snow due to a code change to correct diurnal model specification (i.e., bug fix).

Estimated EBAF High-Resolution Clear-Sky LW TOA Flux Diff (200407)

Estimated Ed4.0 (Method 2)



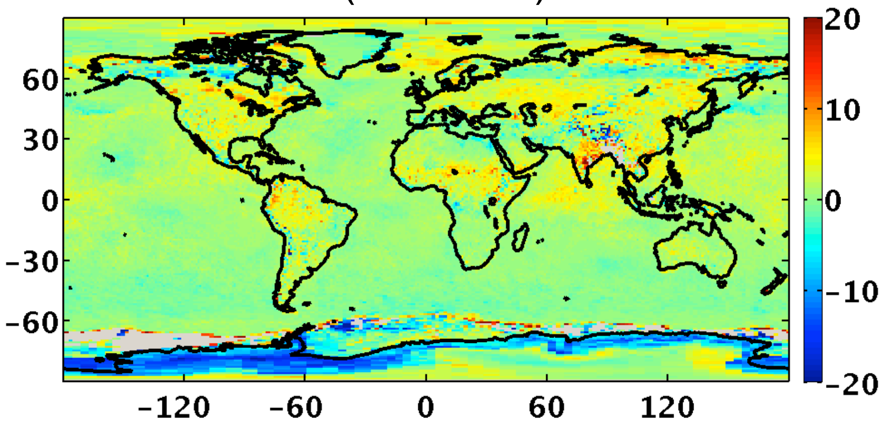
Global mean = 268.7 Wm^{-2}

Caution:

- Impact of new NB2BB is likely overestimated here since not all steps in EBAF clear-sky flux determination are considered here.

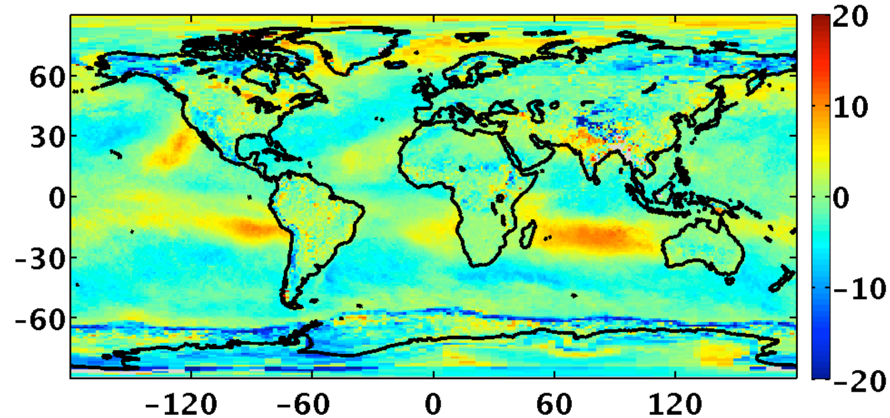
=> NB2BB bias correction against CERES clear-sky flux

Estimated Ed4.0 (Method 1) minus Ed2.8



Global mean Diff = 1.5 Wm^{-2}

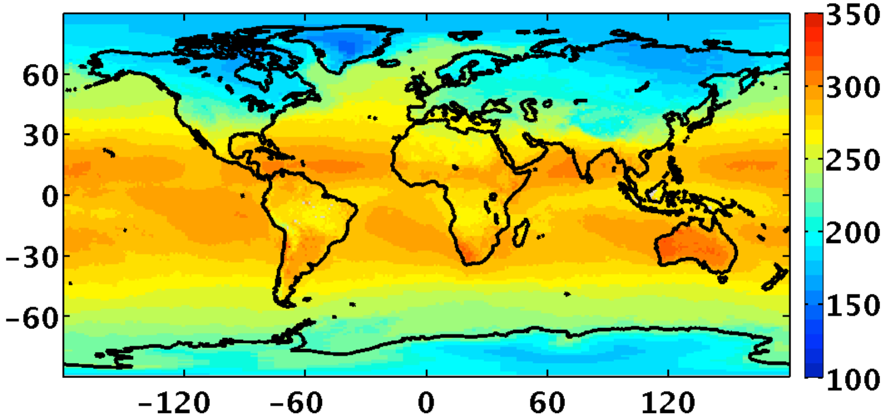
Estimated Ed4.0 (Method 2) minus Ed2.8



Global mean Diff = -1.1 Wm^{-2}

Estimated EBAF High-Resolution Clear-Sky LW TOA Flux Diff (200401)

Estimated Ed4.0 (Method 2)

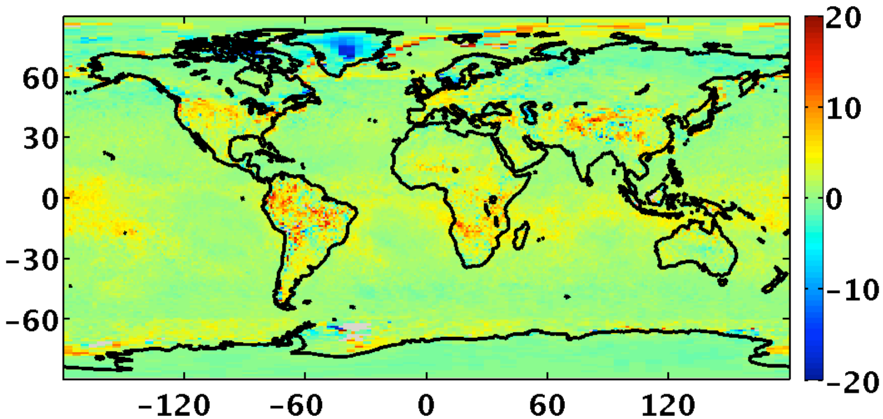


Global mean = 261.8 Wm^{-2}

Caution:
- Impact of new NB2BB is likely overestimated here since not all steps in EBAF clear-sky flux determination are considered here.

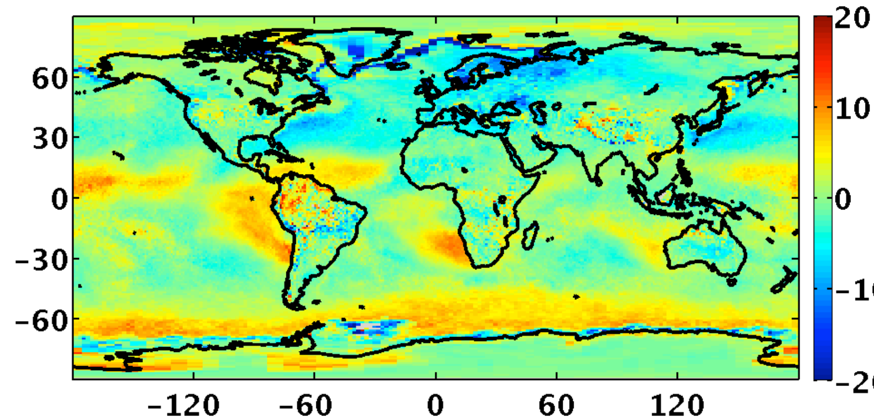
=> NB2BB bias correction against CERES clear-sky flux

Estimated Ed4.0 (Method 1) minus Ed2.8



Global mean Diff = 1.4 Wm^{-2}

Estimated Ed4.0 (Method 2) minus Ed2.8



Global mean Diff = 0.2 Wm^{-2}

Ed 4 EBAF-surface

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[2]Science System & Applications Inc.

EBAF-surface (Ed4) plan

- Use LW spectral irradiances to better constrain downward and upward LW irradiance.
  - Testing the impact on LW spectral is in progress
- Revise the bias correction of downward longwave because Ed 4 SYN accounts for cloud overlap
  - Bias correction is based on cloud overlap comparison using Ed4 SYN and CALIPSO and CloudSat (C3M). Next version of C3M (with Ed4 algorithms) will be used to assess downward longwave bias correction.
  - Low-level clouds are increased from Ed3 to Ed4 (F. Rose presentation). Detecting some marine boundary layer clouds (top less than 1 km) have a larger uncertainty even for CALIPSO (S. Ham presentation). We will investigate low-level clouds in revising downward longwave bias correction.
- Revise the bias correction of OLR with AIRS v006 because reanalysis is switched to GEOS-5.4.1
  - Bias error estimate is based on upper tropospheric relative humidity comparison with AIRS, MERRA2, and ERA-Interim

EBAF-surface (Ed4) plan

- Test a possible use of spectral radiance for T and Q bias corrections
  - Use AIRS radiances and forward spectral radiance computations
  - If successful, ΔT and ΔQ derived from fingerprinting will replace the current bias correction
- Revise the uncertainty estimate used for Lagrange multiplier algorithm.
- Estimate uncertainty in surface radiative fluxes
  - Comparison with surface observations
  - Evaluation of surface radiative flux variability
  - Surface and atmospheric energy balance check

Ed 4 EBAF-surface adjustment process simulation

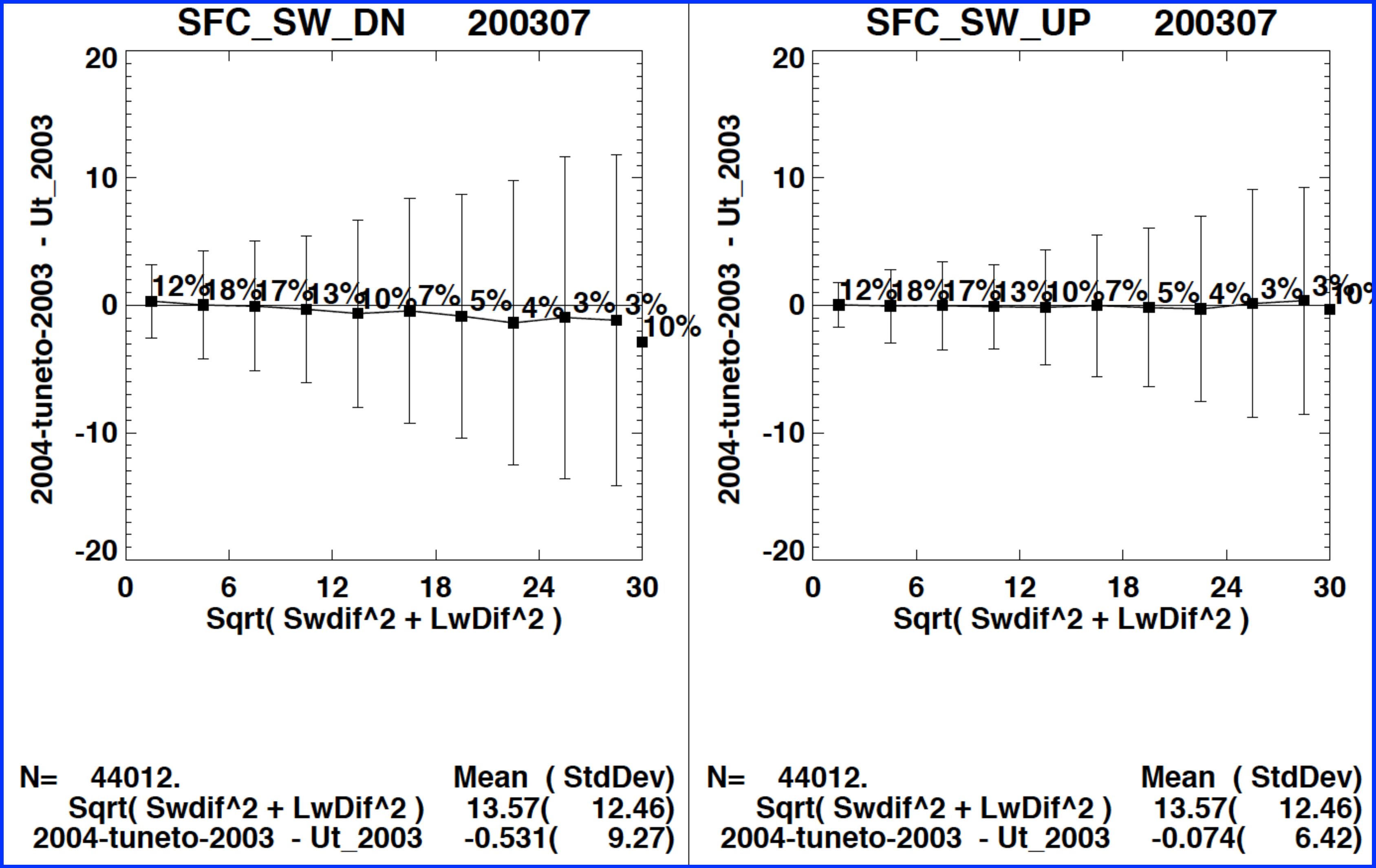
- To evaluate current process indeed reduces the error in surface irradiances
  - Computed SYN 200307 (200407) SW and LW irradiances are tuned to computed SYN 200407 (200307) TOA SW and LW irradiances.
  - Surface SW and LW irradiances are evaluated using 200407 (200307) computed surface irradiances.
- Sensitivity of tuned surface irradiance to initial TOA computed irradiance
  - Use two different months from SYN 200307 and 200407 or and tuned to 200307 or 200407 EBAF-TOA
- To test whether or not spectral information improve surface irradiances, EBAF-surface process (in progress)
  - Add spectral irradiances and evaluate whether or not surface up and downward irradiances improve.

Evaluation of current process

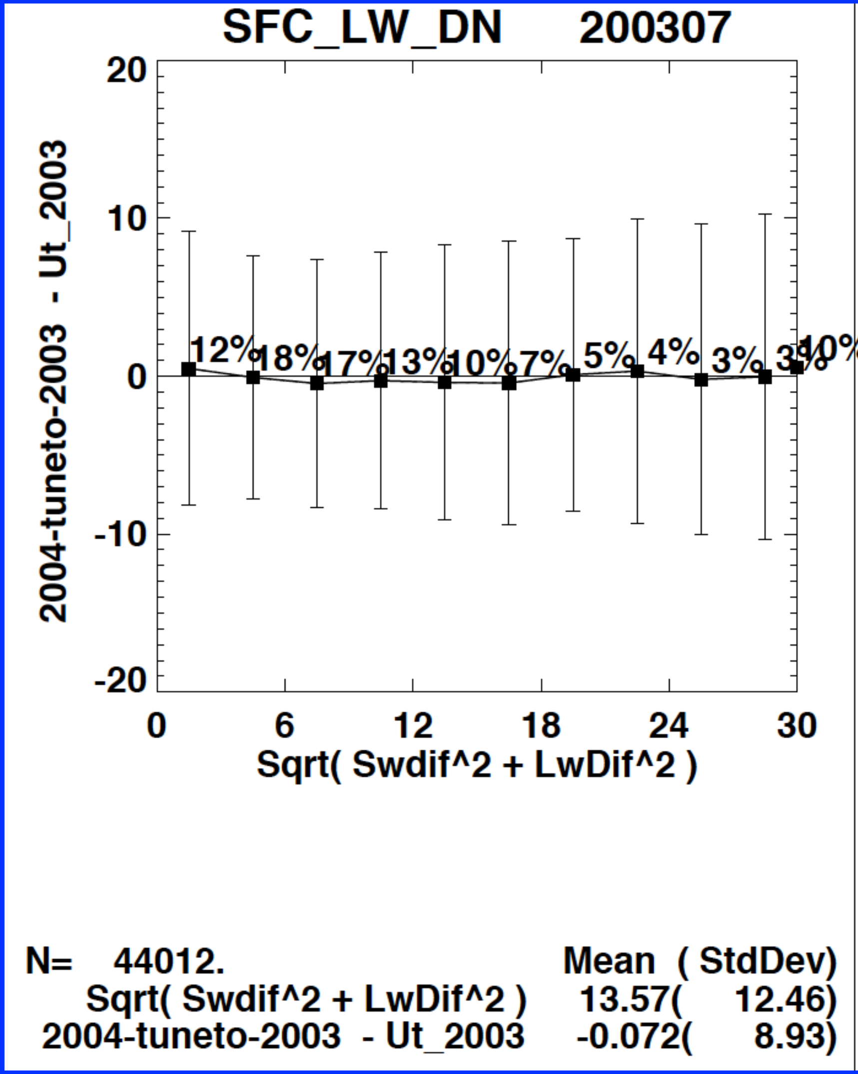
	SYN - SYN-TOA		Tuned surface irradiance difference Different month – correct month (RMS)			
	SW	LW	SW down	SW up	LW down	LW up
Tuned to 200307 SYN						
200307 (EBAF)	-0.462 (5.86)	-2.36 (4.59)				
200407	-0.231 (14.38)	-0.498 (11.51)	-0.521 (9.38)	-0.07 (6.41)	-0.075 (8.92)	-0.465 (9.87)
Tuned to 200407 SYN						
200407 (EBAF)	-0.650 (5.56)	-2.09 (4.30)				
200307	0.231 (14.38)	0.498 (11.51)	-0.676 (8.95)	0.321 (6.13)	4.68 (10.17)	-0.618 (10.23)

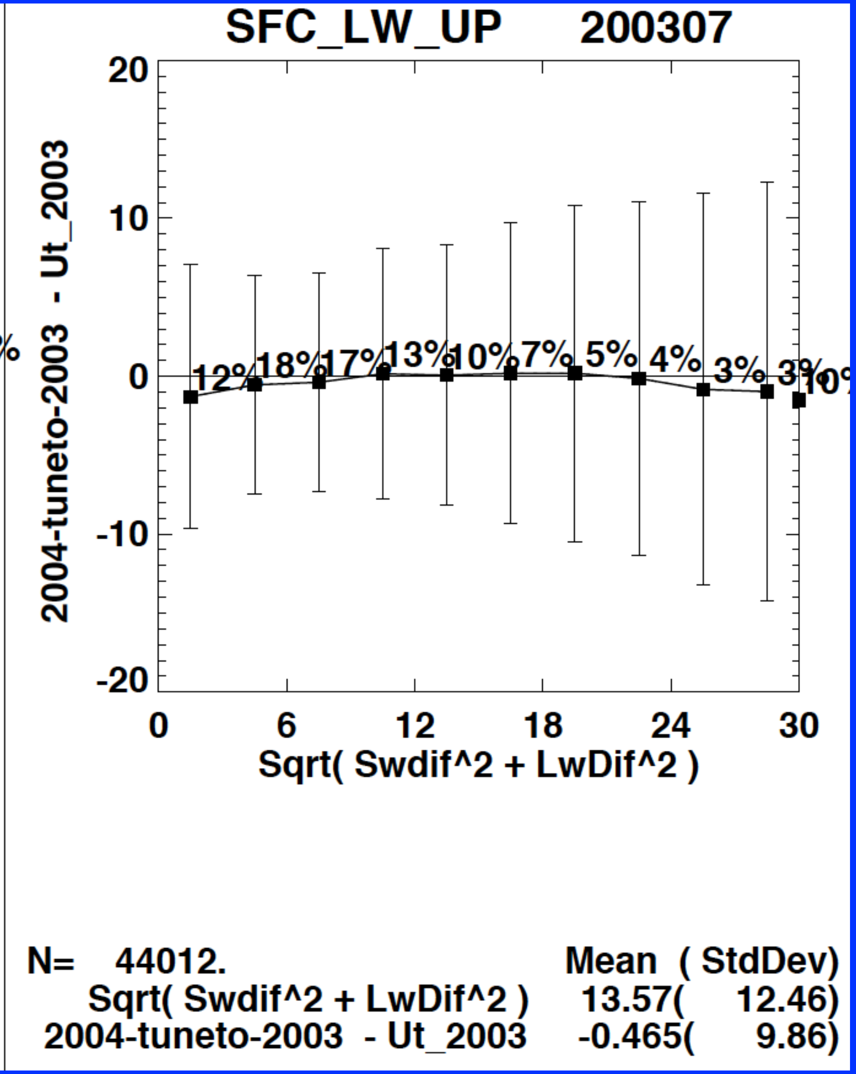
Simulated process needs to correct larger regional differences (larger RMS) than the actual EBAF process

Surface SW


SFC_SW_DN 200307
2004-tuneto-2003 - Ut_2003
Sqrt(Swdif^2 + LwDif^2)
12% 18% 17% 13% 10% 7% 5% 4% 3% 3% 10%
N= 44012.
Mean (StdDev)
Sqrt(Swdif^2 + LwDif^2) 13.57(12.46)
2004-tuneto-2003 - Ut_2003 -0.531(9.27)
SFC_SW_UP 200307
2004-tuneto-2003 - Ut_2003
Sqrt(Swdif^2 + LwDif^2)
12% 18% 17% 13% 10% 7% 5% 4% 3% 3%
N= 44012.
Mean (StdDev)
Sqrt(Swdif^2 + LwDif^2) 13.57(12.46)
2004-tuneto-2003 - Ut_2003 -0.074(6.42)

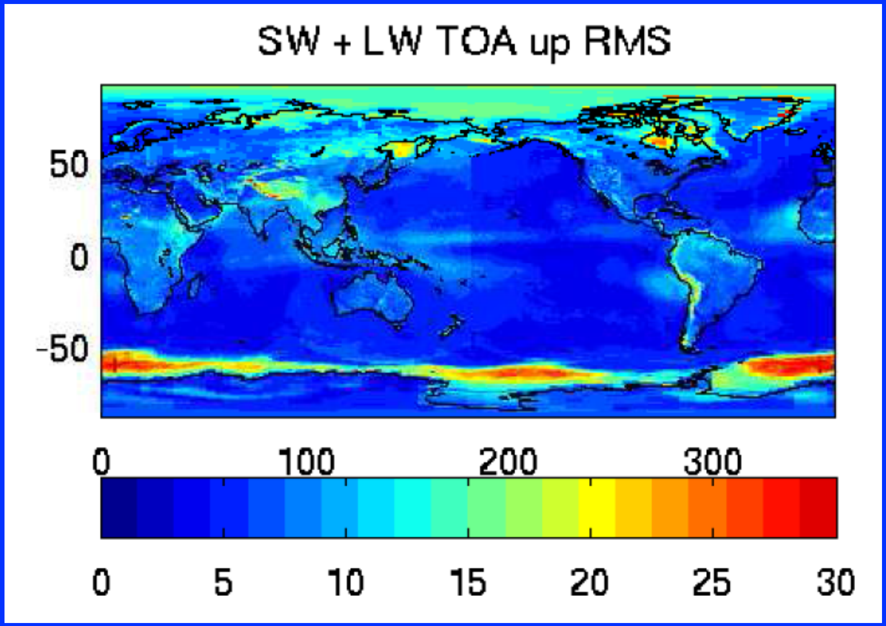
Surface LW


SFC_LW_DN 200307
20
10
0
-10
-20
2004-tuneto-2003 - Ut_2003
0
6
12
18
24
30
Sqrt(Swdif^2 + LwDif^2)
12%
18%
17%
13%
10%
7%
5%
4%
3%
3%
10%
N= 44012.
Mean (StdDev)
Sqrt(Swdif^2 + LwDif^2) 13.57(12.46)
2004-tuneto-2003 - Ut_2003 -0.072(8.93)

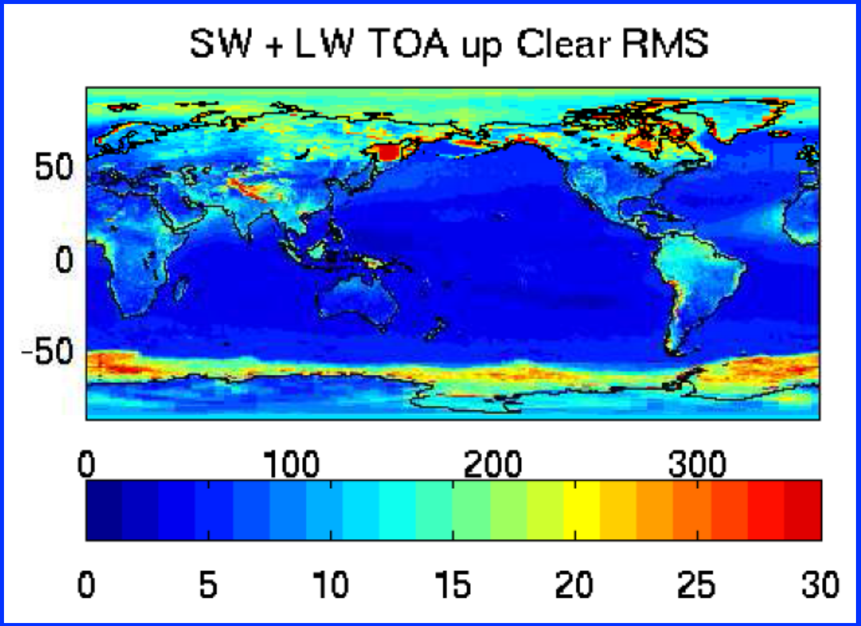

SFC_LW_UP 200307
20
10
0
-10
-20
2004-tuneto-2003 - Ut_2003
0
6
12
18
24
30
Sqrt(Swdif^2 + LwDif^2)
12%
18%
17%
13%
10%
7%
5%
4%
3%
3%
N= 44012.
Mean (StdDev)
Sqrt(Swdif^2 + LwDif^2) 13.57(12.46)
2004-tuneto-2003 - Ut_2003 -0.465(9.86)

Regions with larger surface irradiance uncertainty

All-sky SQRT[$(\text{SW RMS})^2 + (\text{LW RMS})^2$]

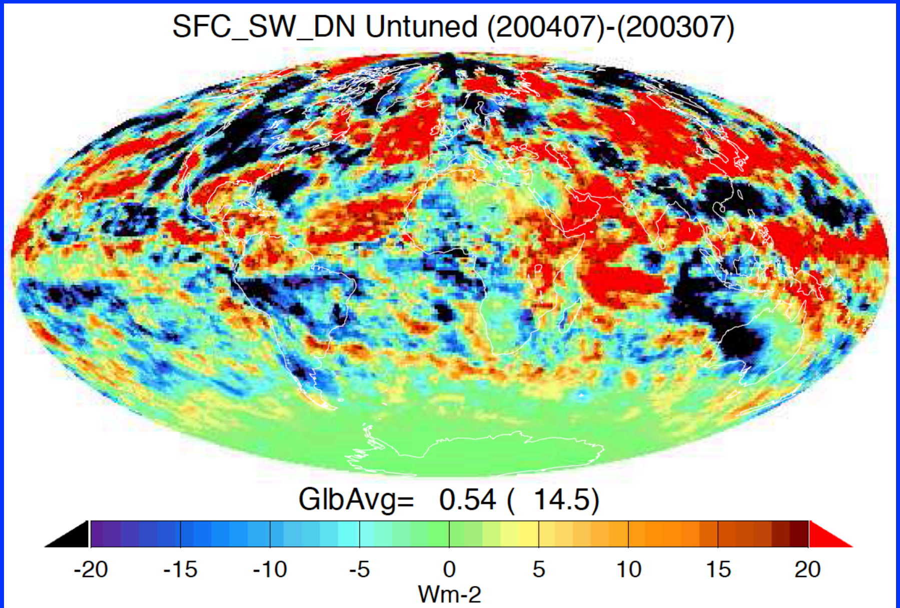


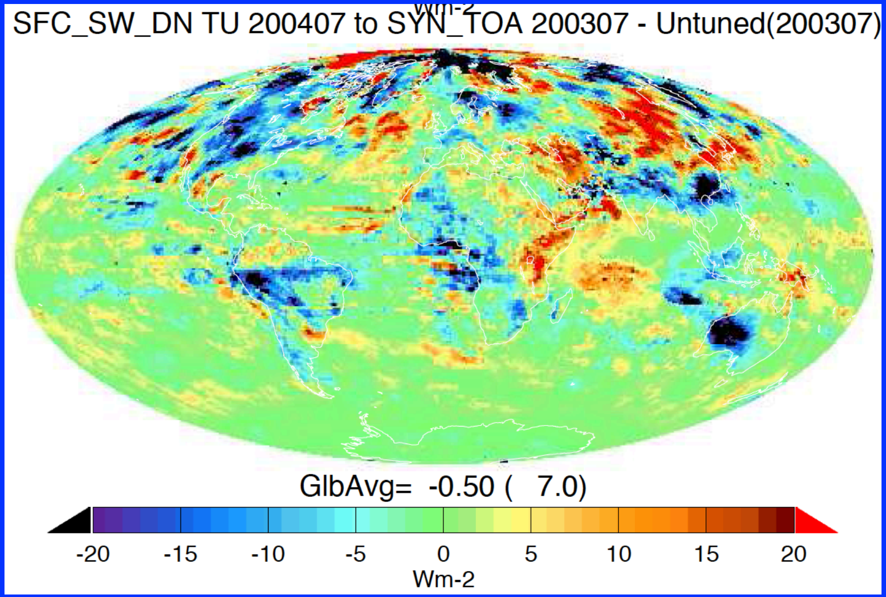
Clear-sky SQRT[$(\text{SW RMS})^2 + (\text{LW RMS})^2$]



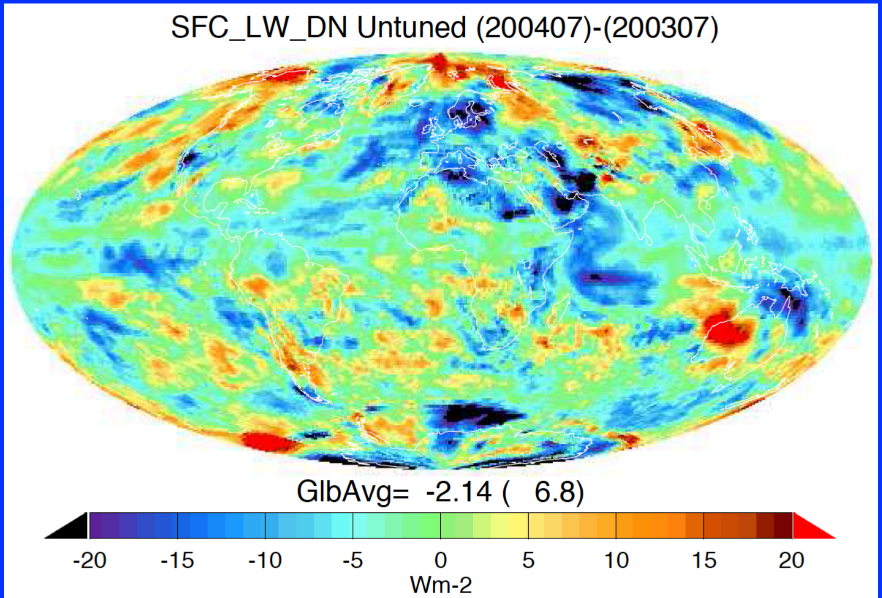
Regions with a larger RMS difference of modeled and observed TOA irradiances often coincide with regions with a larger uncertainty of surface irradiances. Therefore, even though the tuning process adjust surface irradiances, it is necessary to reduce TOA irradiance difference in SYN.

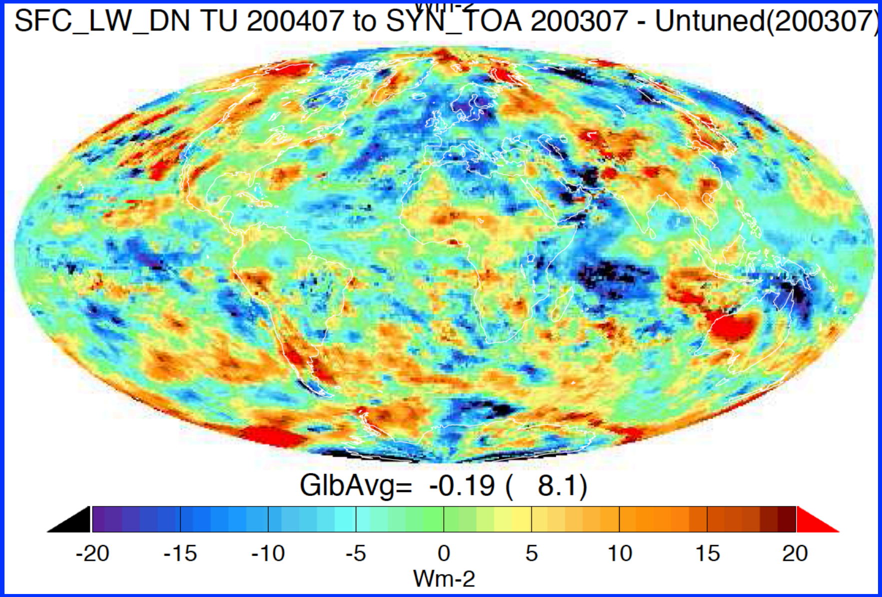
Surface SW down





Surface LW down





Summary of current process

- Surface SW (especially downward) irradiance is constrained by TOA irradiance better than LW.
- When one of computed SW and LW TOA irradiances cannot match TOA observations, it affects both SW and LW surface irradiances.
- When the difference between modeled and computed TOA irradiance is smaller, the uncertainty in the surface irradiance is also smaller (except for LW down).

Sensitivity to initial conditions

- Sensitivity of tuned surface irradiances to initial TOA computed irradiances
  - Use two different months from SYN 200307 and 200407 or and tuned to 200307 or 200407 EBAF-TOA

Dependence to the initial condition

	SYN - EBAF-TOA		Tuned surface irradiance difference Different month – correct month (RMS)			
	SW	LW	SW down	SW up	LW down	LW up
Tuned to 200307 EBAF-TOA			(untune 200407 – untune 200307)			
200307	-0.462 (5.86)	-2.36 (4.59)	0.414 (16.94)	0.102 (6.73)	-2.02 (7.91)	-0.903 (8.13)
200407	-0.691 (15.10)	-2.86 (12.17)	-0.293 (9.78)	-0.106 (6.66)	-2.14 (9.05)	-0.555 (10.09)
Tuned to 200407 EBAF-TOA						
200407	-0.650 (5.56)	-2.09 (4.30)				
200307	-0.420 (15.79)	-1.59 (11.83)	-0.590 (9.56)	0.321 (6.49)	2.67 (9.18)	-0.504 (10.44)

SW down is least sensitive and LW down is most sensitive

LW Spectral irradiance and radiance

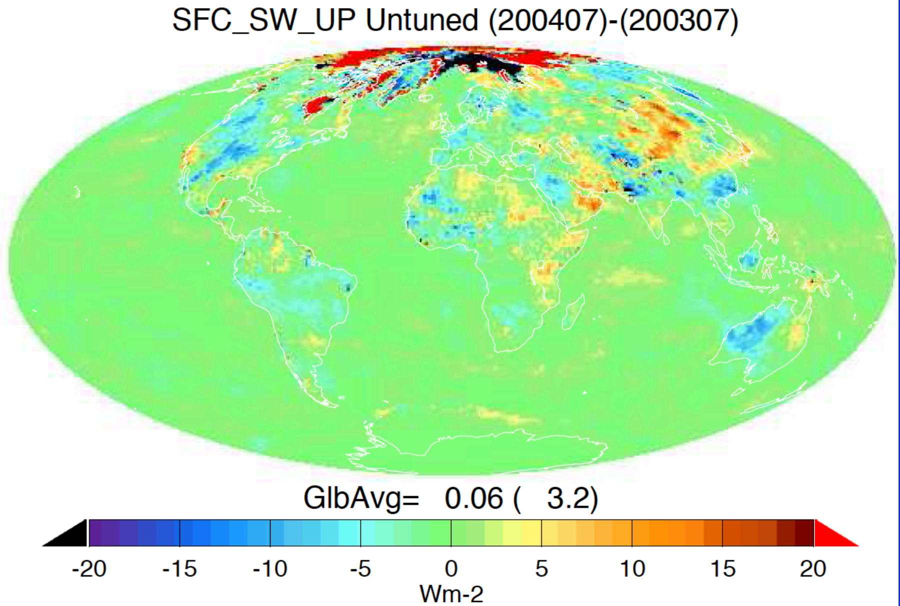
- Test whether or not spectral information improve surface irradiances, EBAF-surface process
  - Add spectral irradiances to the Lagrange multiplier and evaluate whether or not surface LW up and downward irradiances improve.
- Use AIRS spectral radiance to reduce bias error of GEOS temperature and humidity profile
  - Temperature and humidity biases (especially for upper troposphere) are derived. These ΔT and ΔQ will be used for the bias correction in the EBAF process (currently, Level 3 AIRS product is used for the bias correction).

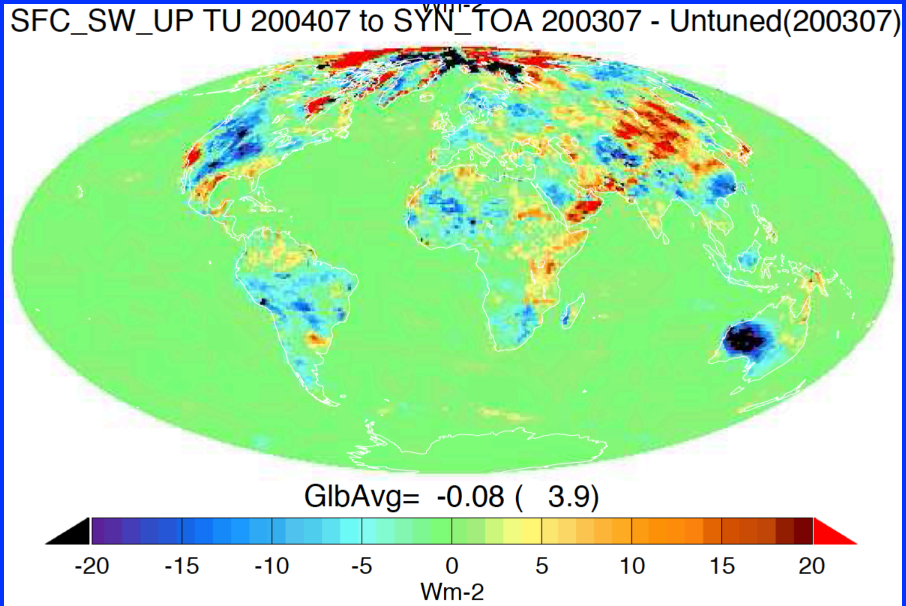
Conclusions

- EBAF Ed4.0 will incorporate the many algorithm improvements in the Edition4 CERES data products (calibration, clouds, ADMs, surface fluxes, time-interpolation, consistent ancillary inputs, etc.).
- The greatest changes will be for clear-sky TOA fluxes at high latitudes.
- Plan is to initially release 5 years (2005-2010) by early 2016.
- EBAF Ed2.8 will continue to be produced until EBAF Ed4.0 catches up.

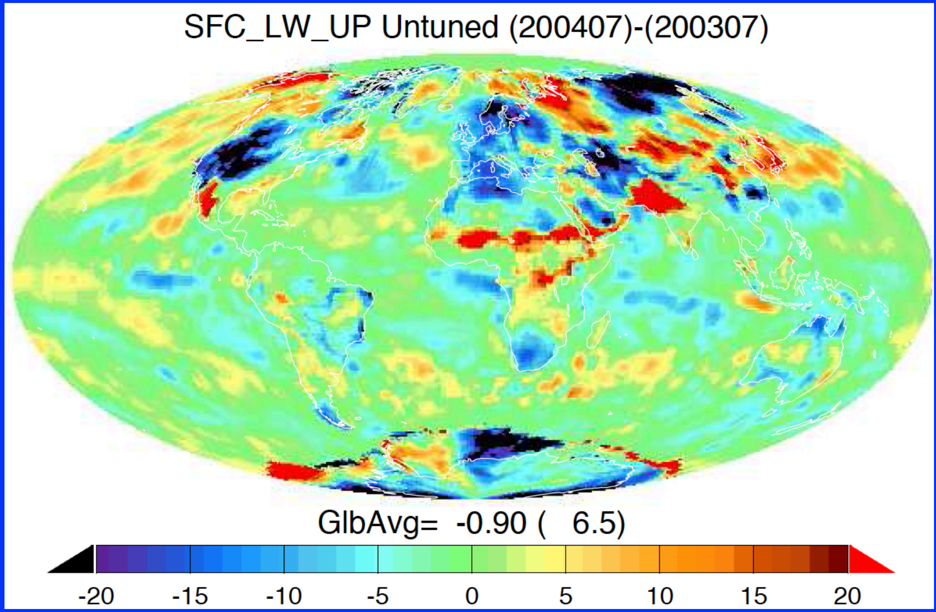
Back-ups

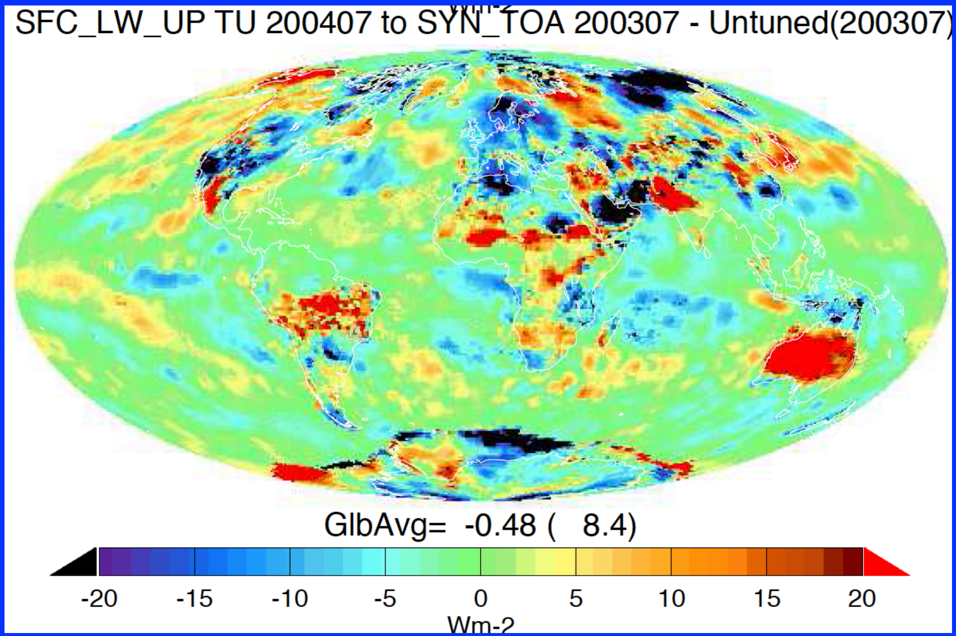
SW up


SFC_SW_UP Untuned (200407)-(200307)
GlbAvg= 0.06 (3.2)
-20 -15 -10 -5 0 5 10 15 20
Wm-2


SFC_SW_UP TU 200407 to SYN_TOA 200307 - Untuned(200307)
GlbAvg= -0.08 (3.9)
-20 -15 -10 -5 0 5 10 15 20
Wm-2

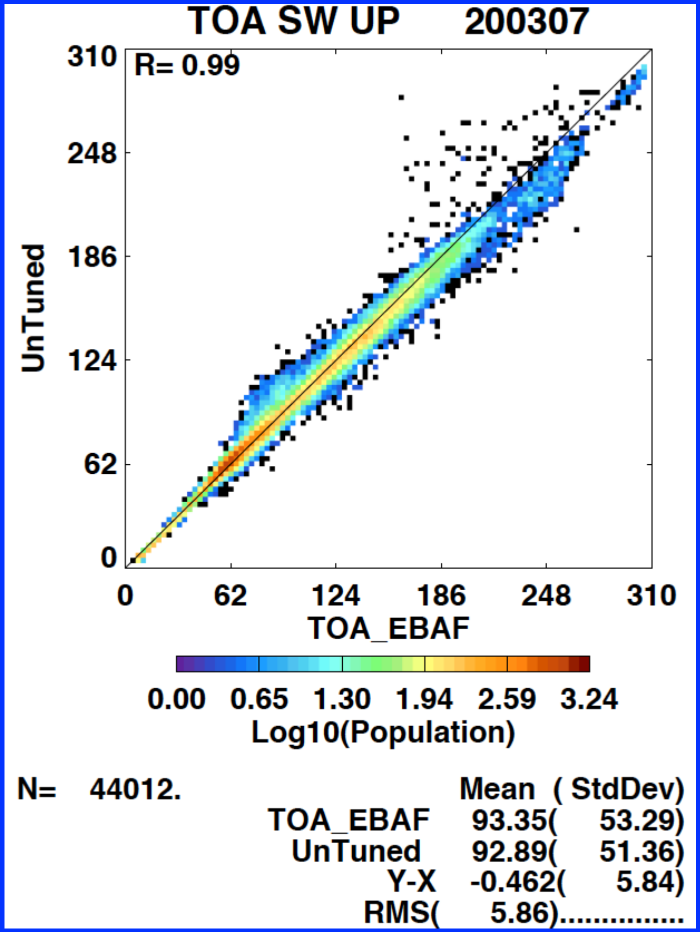
LW up

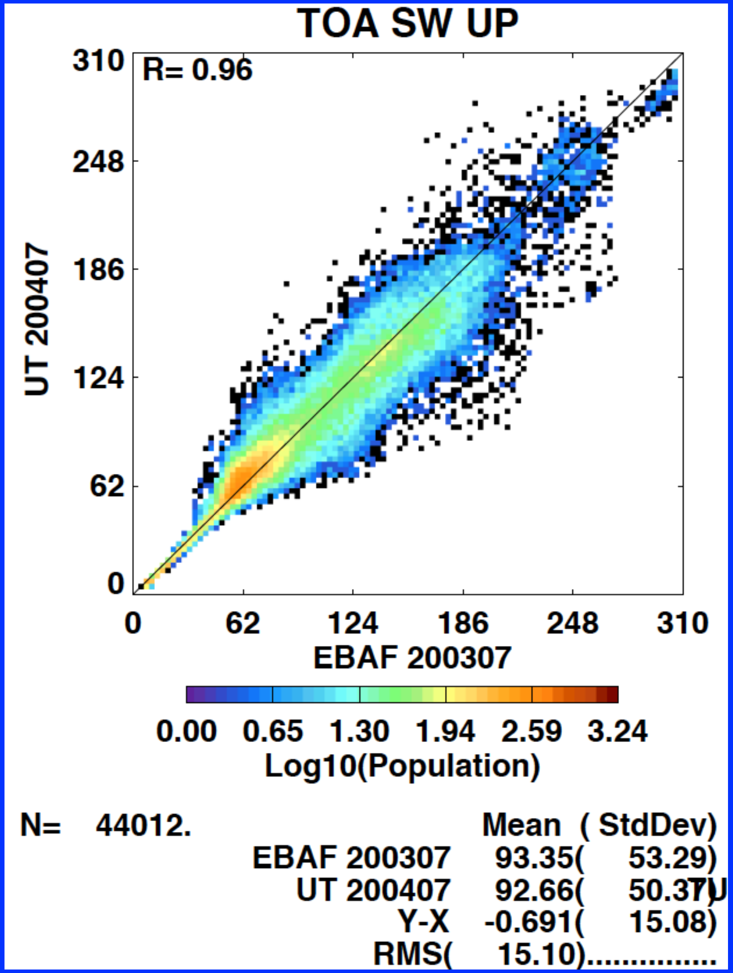




Large tuned error over Australia is due to a large error in SW down
Perhaps, tuning needs to be too large to match TOA SW.

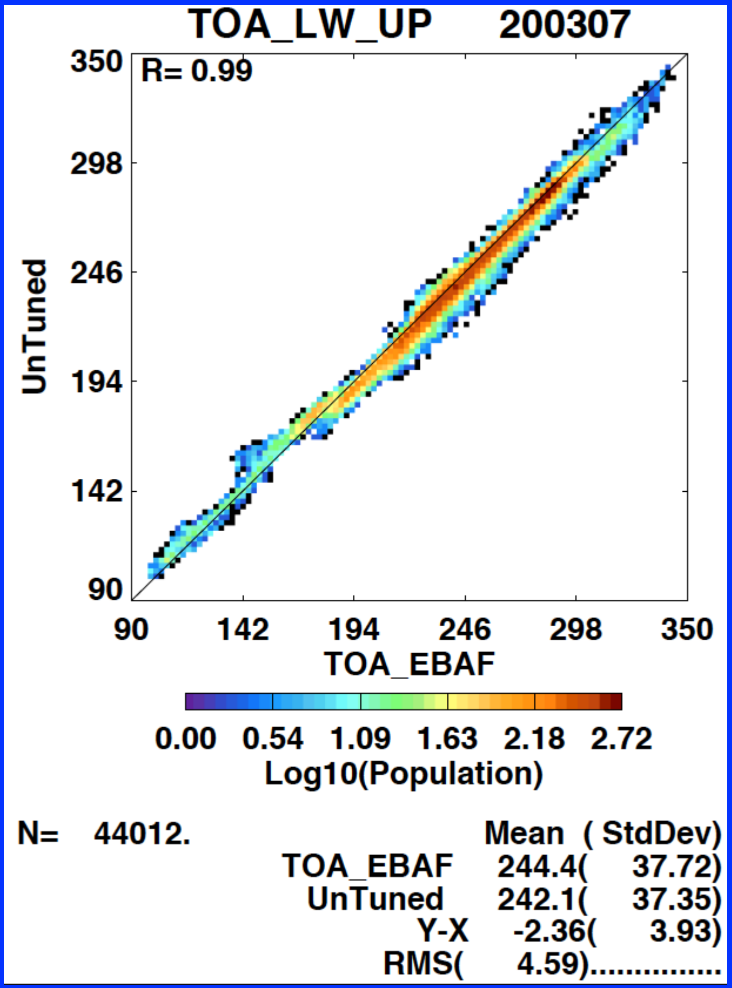
200307 or 200407 tuned to 200307 SW

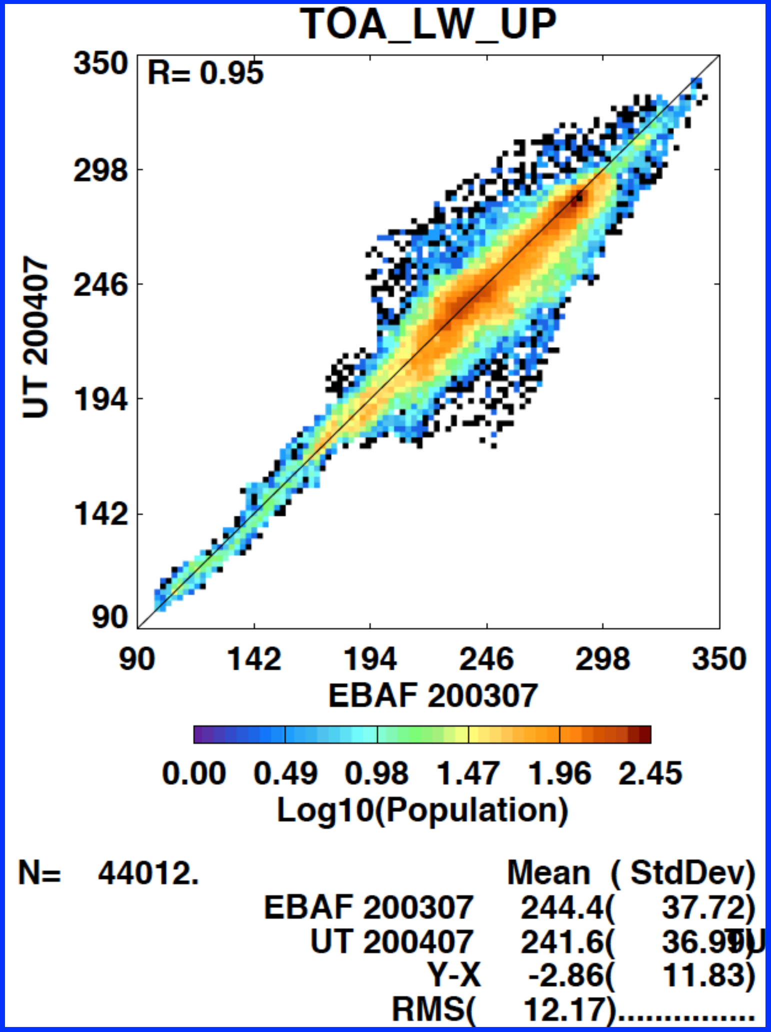




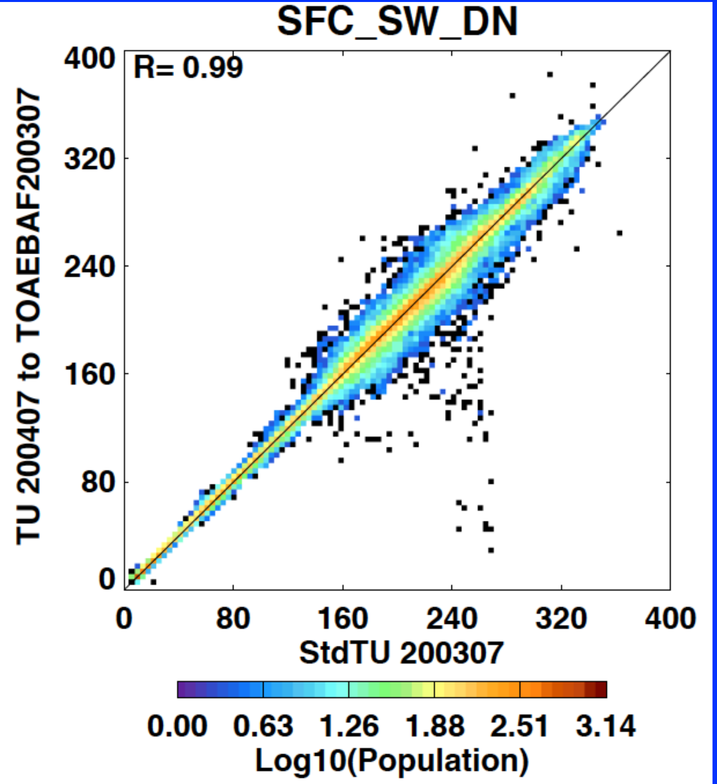
Tuning is larger when different month is used

200307 or 200407 tuned to 200307 LW



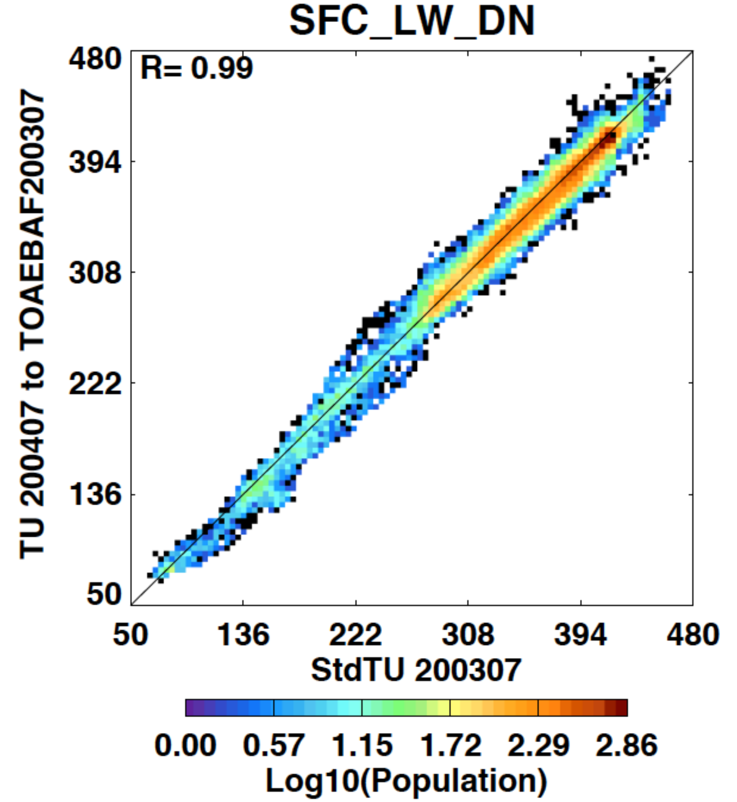


Tuned surface SW and LW down



N= 44012.

	Mean	(StdDev)
StdTU 200307	177.9(	89.54)
TU 200407 to TOAEBAF200307	177.6(	89.23)
Y-X	-0.293(	9.77)
RMS(	9.78)...............	



N= 44012.

	Mean	(StdDev)
StdTU 200307	353.3(	65.46)
TU 200407 to TOAEBAF200307	351.1(	65.23)
Y-X	-2.14(	8.80)
RMS(	9.05)...............	